NATIONAL BUREAU OF STANDARDS REPORT

8679

PERFORMANCE TEST OF
HI-FLO AEROSOLVE 3P-85 AND HI-CAP 45 HC1500 FILTERS

manufactured by Cambridge Filter Corporation
Syracuse, New York

by

Charles M. Hunt and Paul R. Achenbach

Report to
General Services Administration
Public Buildings Service
Washington, D.C.

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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1. Introduction

At the request of the Public Buildings Service of the General Services Administration, the performance characteristics of Cambridge Hi-Flo aerosolve filters, model 3P-85, and Cambridge Hi-Cap filters, model HC1500, were determined. The scope of the investigation included determination of arrestance and pressure drop across the filter at the rated flow of 1500 cfm as the dust load was increased from zero to a final value corresponding to a pressure drop of approximately 1 inch for the Hi-Flo and 0.6 inch for the Hi-Cap filter. Atmospheric dust was used as the test aerosol in the determination of the arrestance of the Hi-Flo filter and Cottrell precipitate with the Hi-Cap filter.

2. Description of Test Specimens

The filters were supplied by the Cambridge Filter Corporation of Syracuse, New York. The Hi-Flo 3P-85 filter was of the deep-bed dry media type, having outside face dimensions of 23 3/8 x 23 3/8 inches and depth of 21 inches. The measured face dimensions of the test specimens, not including the mounting frame, was 21 7/8 x 21 7/8 inches. The filter surface was subdivided into ten vertical pockets. The measured depth of each pocket was 20 inches and the height was 24 inches. The estimated area of the media was 67 ft^2, which is in reasonable agreement with the nominal area of 70 ft^2 given by the manufacturer.

A square metal frame, attached at the upstream end, was an integral part of each Hi-Flo 3P-85 filter. Vertical cross members of the frame were attached to each pocket at the face of the filter.

The downstream surface of the Hi-Flo 3P-85 filter consisted of a highly porous paper or nonwoven cloth backing. A simple flame test indicated the material to be cellulosic in nature. It had great tear resistance which suggests impregnation with a polymer. The body of the filter itself consisted of glass fibers which were about 3 microns in diameter.

The Hi-Cap HC1500 filter consisted of an extended-area disposable media cartridge which fit into a permanent frame. The media cartridge was subdivided into four pockets. A detachable, heavy wire retainer fitted the convolutions of the filter media on the downstream side.

The filter had outside face dimensions of 23 1/2 x 23 1/2 inches and a depth of 9 inches. The measured face dimensions, exclusive of the frame, were 22 7/8 x 22 7/8 inches, and the pockets were about 8 7/8 inches deep with a height of 23 inches. The estimated area of the filter media was about 15 ft^2.

The filter media, according to the manufacturer is a modified acrylic fiber. Diameters of the individual fibers under the microscope were approximately 75 microns.

The Hi-Cap filter media was coated with an oily adhesive which imparted an amber color to the filter. Small droplets of adhesive were visible on the fiber, but there was no evidence of drainage due to excess adhesive.

3. Test Method and Procedure

The filters were tested at the rated air flow of 1500 cfm. The arrestance determinations of each specimen were made with the NBS Dust Spot Method described in a paper by R. S. Dill entitled, "A Test Method for Air Filters", (ASHVE Transactions, Vol. 44, page 379, 1938). The filter under test was installed in the test apparatus and carefully sealed to prevent any by-pass of air, or inward flow of air into the test apparatus, except through a measuring orifice. After establishing the correct air flow rate through the filter, samples of air were drawn from the center points of the test duct 2 feet upstream and 8 feet downstream of the test specimen. Each sample of air was passed through Whatman No. 41 filter paper. The arrestance measurements of the Hi-Flo filter were carried out using the particulate matter in laboratory air as the test aerosol. Arrestance of the Hi-Cap filter was measured with Cottrell precipitate, except that an initial arrestance measurement with the unloaded filter and a final measurement of the fully loaded filter were performed with laboratory air.

The light transmission of the sampling papers was measured on the same area of each paper before and after test, and the two sampling papers used for any one arrestance determination were selected to have the same light transmission when clean.

In determination of the arrestance of laboratory air, some of the values were obtained with the timer and some were obtained with sampling plates of different area. These devices are commonly used to obtain

dust spots of nearly equal opacity on the upstream and downstream sampling papers, a requirement for accurate arrestance measurements. In the timer method this is achieved by sampling through the upstream filter paper only part of the time while operating the downstream sampler continuously. This time-proportioning was accomplished by the use of one solenoid valve in the upstream sampling line and another in a line by-passing the sampler. The solenoid valves were operated by an electric timer and a relay so that one was open while the other one was closed during any desired percentage of a 5-minute timer cycle reversing the position of the two valves during the remainder of the cycle. The arrestance A, (in percent), was then determined with the formula:

$$A = 100 - T \frac{\Delta D}{\Delta U}$$

where T is the percentage of time during which air was drawn through the upstream sampler, ΔU and ΔD are the observed changes in the opacity of the upstream and downstream sampling papers, respectively.

In the method where sampling plates of different areas were used, the arrestance was calculated using the following formula:

$$A = 1 - \frac{S_D}{S_U} \times \frac{\Delta D}{\Delta U} \times 100$$

where the symbols A, ΔU, and ΔD represent the same quantities as indicated above, and S_U and S_D are the upstream and downstream sampling areas, respectively.

For determination of the arrestance of Cottrell precipitate, plates of different area were employed and the latter formula was used for calculation of arrestance.

Arrestance measurements were made with the unloaded filter and after increments of test dust were introduced to the filter by dispersion in the upstream air. The loading dust consisted of 96 parts by weight Cottrell precipitate and 4 parts by weight cotton linters. The Cottrell precipitate had been previously passed through a 100-mesh sieve, and the lint was prepared by grinding No. 7 cotton linters in a large Wiley mill equipped with a screen with 4-mm holes.

The pressure drop across each filter was measured at the beginning of the test and after each addition of loading dust. The Hi-Flo 3P-85 filter was loaded until a pressure drop of approximately 1 inch W.G. was obtained. This is greater than the final pressure drop of 0.6 inches W.G. suggested for similar filters in Cambridge Bulletin 134 (1962). It was done to provide additional test data, since there is no GSA specification for this type filter. The Hi-Cap HC1500 filter was loaded until a pressure drop of approximately 0.6 inches W.G. was obtained. This is the recommended final pressure drop for Hi-Cap filters given in Cambridge Bulletin 150 (1963).

Although the Hi-Cap HC1500 filter contained an adhesive, it was tested with the view of comparing its performance with the requirements for a type-C filter according to General Services Administration "Standard Airconditioning Specification" of December 1964. This specification calls for a dust-holding capacity of "not less than 275 grams of dust per 1000 cfm of specified capacity when the resistance to air flow reaches 0.50 inch water gage". The specified capacity of this filter is 1500 cfm which corresponds to a dust-holding capacity of 413 grams according to the specification.

The tests of the Hi-Flo 3P-85 filter were performed with a single specimen. However, initial pressure drop and initial arrestance of atmospheric dust were carried out on a second filter of the same type. The tests of the Hi-Cap HC1500 were repeat measurements of this type filter after an earlier specimen with a different adhesive was found to have very high dust-holding capacity but had an arrestance with Cottrell precipitate slightly lower than the specification requirement of 80%.

4. Results

The arrestance of atmospheric dust and pressure drop of a Hi-Flo 3P-85 extended-area, dry media filter before and during loading is given in Table 1. These data are plotted in Figure 1 where the upper curve represents arrestance and the lower curve represents pressure drop, both plotted as functions of nominal dust load.

TABLE 1

Performance of Cambridge Extended-Area,
Dry Media Hi-Flo Filter, Model 3P-85, at 1500 cfm

Nominal[a] Dust Load (grams)	Pressure Drop across Filter (inches W.G.)	Arrestance of Atmospheric Dust (percent)		
		Timer	Sampling Plates	Average Time and Variable Area
Filter A				
0	0.250	67.3	71.5	69.4
208	.282	--	73.4	--
500	.346	--	76.5	--
812	.450	78.9	80.0	79.6
1021	.590	85.8	85.8	85.8
1229	.802	86.9	88.6	87.7
1396	1.014	88.3	--	--
Filter B				
0	0.238	--	68.1	--

[a]Nominal dust load is the total weight of precipitate and linters introduced into the test duct. The actual load retained by the filter is less by the amount which passes the filter.

The pressure drop of the Hi-Flo 3P-85 filter increased from an initial value of 0.250 inches W.G. with the unloaded filter to a final value of 1.014 inches W.G. after a dust load of 1396 grams had been added. The dust load corresponding to a pressure drop of 0.6 inch W.G., the final pressure recommended by the manufacturer, was about 1035 grams. The second Hi-Flo 3P-85 filter had an initial pressure drop of 0.238 inches.

The initial arrestance of the unloaded filter was 69.4% and the final arrestance was 88.3%. The calculated average arrestance, based on the area under the upper curve in Figure 1, was 76.9% up to a pressure drop of 0.6 inch W.G. and 79.2% up to 1 inch W.G. Each of these values is about 0.2% lower than the estimates made in a letter of March 22nd to Mr. Donald N. Whitmeyer giving a tentative report of these test results. This is because they give slightly greater weight to the arrestance values obtained with the timer than the earlier values.

The arrestance and pressure drop of the Hi-Cap HC1500 filter in the unloaded condition and with increasing dust load is given in Table 2. In Figure 2 the upper curve represents arrestance of Cottrell precipitate as a function of nominal dust load while the lower curve is a similar plot of pressure drop.

TABLE 2

Performance of Cambridge Hi-Cap Extended Area,
Disposable Cartridge Filter, Mod. 45 HC1500
at 1500 cfm

Nominal[a] Dust Load (grams)	Pressure Drop across Filter (inches W.G.)	Arrestance of Cottrell Precipitate (percent)	Arrestance of Atmospheric Dust (percent)
0	0.166	70.0	9.4
220	.206	78.0	--
637	.274	81.8	--
1062	.354	84.3	--
1486	.468	86.1	--
1903	.630	89.0	36.6

[a]See footnote "a", Table 1.

An initial pressure drop of 0.166 inches W.G. was obtained with the Hi-Cap HC1500 filter, and a final pressure drop of 0.630 inches W.G. was obtained after 1903 grams of dust had been fed to the filter. The dust load corresponding to a pressure drop of 0.5 inch W.G. was estimated to be 1590 grams, or 1060 grams per 1000 cfm of specified capacity, which is well in excess of the GSA specification requirement of "275 grams of dust per 1000 cfm of specified capacity when the resistance to air flow reaches 0.50 inch water gage".

The arrestance of Cottrell precipitate increased from an initial value of 70.0% with the unloaded filter to 89.0% after a pressure drop of 0.630 inches W.G. had been reached. The average arrestance, calculated from the curve in Figure 2, was 82.3% when integrated up to a pressure drop of 0.5 inches W.G. This is within the specification requirement of 80% arrestance.

An arrestance of 9.4% for atmospheric dust was obtained with the unloaded filter, but this rose to 36.6% for the fully loaded filter.

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EXTENDED AREA, DISPOSABLE CARTRIDGE
CAMBRIDGE FILTER
MODEL 3P - 85

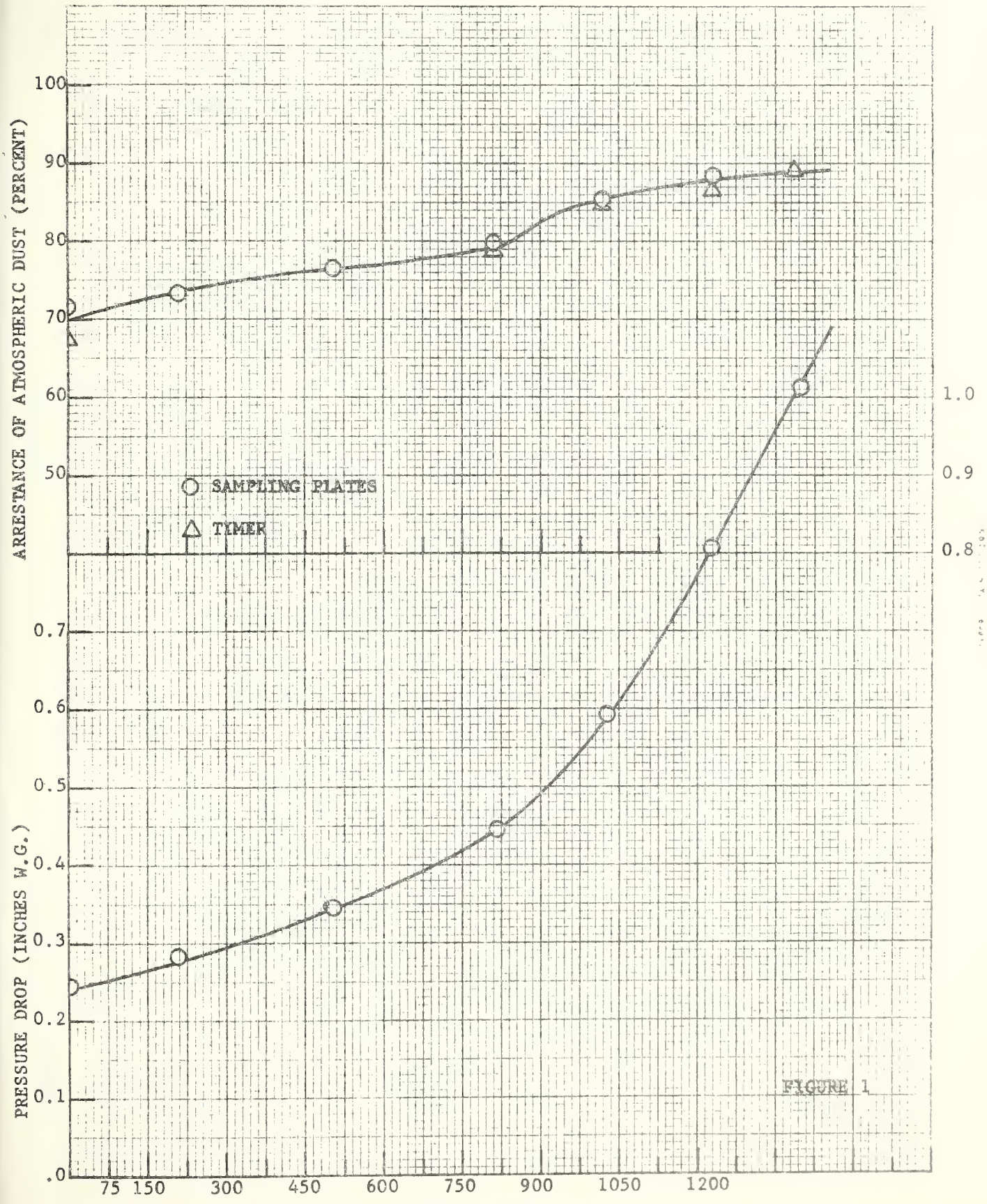

FIGURE 1

EXTENDED AREA, DRY MEDIA
CAMBRIDGE FILTER
MODEL 45 HC 1500

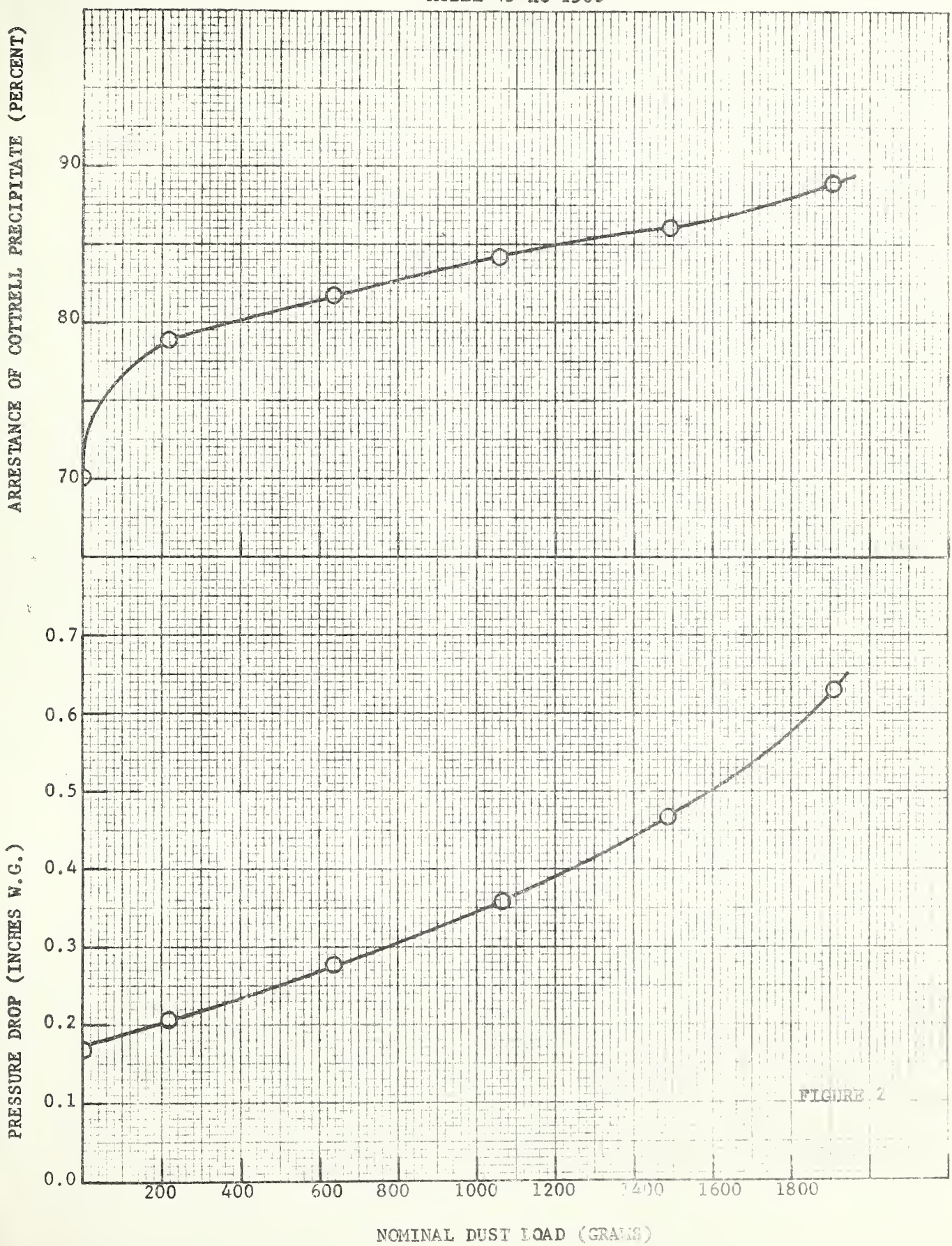

FIGURE 2


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